AD-A139 106 EVALUATION OF THREE WATERING AND MULCHING TECHNIQUES ON TRANSPLANTED TREES AT ADOBE DAM(U) ARIZONA STATE UNIV TEMPE CENTER FOR ENVIRONMENTAL STUDIES C MOORE JUN 83 1/1

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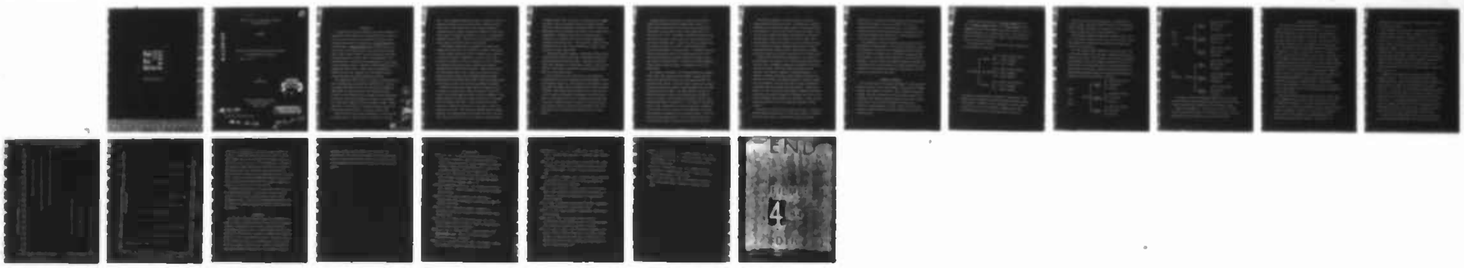

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Report to the U. S. Army Corps of Engineers
Los Angeles District

Task ~~No.~~ 6

Evaluation of Three Watering and Mulching Techniques on Transplanted Trees at Adobe Dam

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By
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INTRODUCTION

On denuded lands, harsh site conditions may render revegetation by seeding risky and the probability of seeding failure high. Success in these areas can be achieved using transplants of suitable species. Studies using three month old transplants of *Atriplex canescens* and transplant plugs of *Agropyron smithii* showed survival rates 50 to 75 percent greater than seeded plants on coal spoils (Packer and Aldon 1978). While increased survival rates make transplant use desirable, high costs limit use to critical areas. On more favorable sites, transplanting may be appropriate for landscaping value. Here, planned land use determines economic feasibility; increased expenditures may be justified for high use areas. Whether harsh site conditions or aesthetic motives direct transplant use, the investment should be protected by proper planting and maintenance operations.

Soil preparation should be kept to a minimum, as transplants must be able to establish and to be supported in available soils. When soil evaluations reveal shallow soils of less than two feet (Wildman and Gowans 1978), or low soil fertility, major modifications may be necessary for good transplant growth. Seeding of tolerant species may be preferable. Where heavy equipment has traveled or an impermeable soil layer exists, compaction should be relieved by ripping. Grading operations to create contours for transplant placement, enhance water harvesting and highly advisable in arid regions (McKell 1978).

Plant selection should be based on adaptability to site conditions and planned land use. Several choices are available to transplant

users. Young seedlings transplanted as plugs or tublings can afford low maintenance vegetative cover if planting occurs in favorable seasons (Hodder 1977). With increased size, comes increased maintenance, including initial and probably supplemental irrigation for desert sites. Larger plants are available as burlap ball, bare root, or containerized transplants (Harris 1978). Container plants are most widely used and exhibit higher survivability (Packer and Aldon 1978).

Caliper/height specifications are commonly set by arborists and landscape architects, while root conditions are ignored. More and more successful agencies specify that trees be inspected for root defects as a condition of delivery. Unfortunately, top vigor is not a good indicator of the quality of the roots (Harris et al. 1971). Defective root systems can lead to poor growth, breakage and even death of transplant species (Barrows 1970, Long 1961). Defects in the main tap root, major branch roots or both, include roots sharply bent from a normally straight extension, and circling/girdling roots growing horizontally around the trunk (Harris 1967). Should these defects occur in the surface or center root zones poor establishment is probable.

Inspection of surface roots should involve the removal of soil to 2-3" depth 1-2" from the trunk. However, if branched roots are not visable in the initial inspection, deeper probing is recommended. Often nursery grown stock is planted too deeply, risking crown rot infection and other problems (Pirone 1972). Center roots may not be easily viable, and to examine this root zone, it is necessary to remove the container and some soil. This destructive sampling should be conducted sparingly. When observed defects in the surface and center root zones involve 80 percent or more of the root, satisfactory plant performance

is doubtful (Harris 1978). Matted roots at the bottom of the container and masses of root in and around the root ball indicate pot bound conditions (California Department of Agriculture 1968). Seriously pot bound plants will also display poor top vigor and are bad candidates for transplanting. Peripheral circling and less serious pot bound conditions can be corrected at the time of planting by pruning and straightening the affected roots. Failure to correct these root defects or bending tap roots at the time of transplanting can lead to future girdling of the plant (Harris 1978).

Plants selected should be vigorous. Examine bark, leaves and roots. Smooth bright bark indicates good vigor on young plants, whereas dull, cracked rough bark may denote poor vigor. Leaves should be green to bright green, depending on the species and the season. Young roots are light in color and darker roots may result from low vigor or a plant small for its age (Harris 1978).

Several container sizes are available for use in reclamation. Fifteen gallon sizes are more expensive than the more commonly used one and five gallon transplants. They are generally more difficult to plant and require more intense initial maintenance than the smaller container transplants. When larger trees are selected, root to shoot ratios are critical; frequent fertilizations and waterings in the nursery often induce top heavy growth that can not be sustained in field conditions. A tree with a moderately sized top in relation to the root will grow more vigorously than large top-heavy trees (Hendrickson 1918). Top heavy plants should be pruned when planting but may still require staking.

Staking in general is undesirable, if possible, plants selected should be self-supporting and still possess lateral branches. In studies comparing nonstaked trees with staked trees, nonstaked trees showed greater caliper, greater tapor and less height (Harris et al. 1967, Leiser et al. 1972). Additionally, nonstaked trees have less wind resistance and therefore less stress per unit cross sectional area of trunk (Leiser and Kemper 1973). Larger root systems on nonstaked trees were observed by Leiser et al. (1972). Lateral branches proved important in development of caliper and tapor. In comparison of lightly pruned lateral branches (10-12") and heavily pruned laterals (4-6"), lightly pruned plants showed greater califper, less height, and more tapor (Harris and Hamilton 1969). A combination of minimum staking and minimal pruning of lateral branches is recommended for best results (Harris 1978).

When staking is unavoidable, the following guidelines are suggested (Harris 1978). Make stakes as short as possible. Staking height is properly six inches above the point where the lightly deflexed trunk snaps back to the vertical. Staking too high or leaving the top lateral exposed and unsupported can lead to severe deformation, due to the high stress borne by the top leader. Two stakes should be used and ties should allow flexible movement while preventing contact between the trunk and the stakes. The tree should be supported at one level only, allowing movement above and below the tie. Use stakes for the shortest possible period. Removal after the first growing season is suggested. If at this time, the tree is unable to stand unsupported, the staking height should be redetermined and the tree lightly pruned. If after the second and third growing season the tree still requires staking, poor root development or other problems may be the cause of a weak trunk.

When planting transplants, holes dug by backhoe are superior to auger bored holes (Ribera and Sue 1978). The combination of nonglazed roughened sides and noncircular shape encourage root development outside the planting hole. The hole itself should be twice the diameter of the root ball and no deeper than necessary; approximately two inches less than the depth of soil in the container or root ball (Harris 1978). Plants planted too deeply are subject to crown rot as mentioned earlier. It is advisable to add slowly decomposing organic matter to heavy or sandy soils when back filling the hole. Plants should be thoroughly watered after planting to settle the soil around the tree (Harris 1978).

During the first week following transplanting, it is critical to maintain adequate soil moisture, due to limited rooting volumes (Packer and Aldon 1978). Supplemental irrigation may be required in arid areas after the first week. Aldon (1975) reported significantly lower survival of nonirrigated as compared to irrigated transplants. In addition to increased survivorship, briefly irrigated transplants were double the size of their nonirrigated counterparts. Minimum irrigation for plant maintenance in dry areas followed by a gradual withdrawal of supplemental water is recommended (Ries and Day 1978). On deep soils, Sachs et al. (1975) reported that one irrigation scheduled in mid-summer was sufficient to maintain drought hardy transplants near San Jose. Too frequent irrigation induces minimum root development, is costly, and may induce lush growth that can not be supported by naturally occuring moisture.

The addition of mulch can reduce watering requirements. Benefits of mulching include; moderation of soil temperatures, reduction of moisture loss and erosion control. Many mulches are available and careful

evaluation aids in selection of appropriate mulch. Cost considerations should not only include the price of the mulch, but the cost of transporting the mulch to the reclamation site. To be effective, a mulch must remain in place during watering and in windy weather. Ease of appliation should also be considered. A slowly decomposing mulch will remain effective longer (Harris 1978).

More information is needed on minimum irrigation schedules and the suitability of differing mulches. The Army Corps of Engineers provided the opportunity to test three watering regimes and mulching techniques on their Adobe Dam reclamation site. Additionally, fencing practices were evaluated. To accomplish these objectives, a two-part study was conducted. A two-part study was made manditory because the project area is divided into east and west sections by a heavily trafficked road, and furthermore, the east section was planted in early February, while the west section was planted in early April.

MATERIALS AND METHODS

For the first study, on east section transplants, a simple factorial design was selected to test watering regimes. After one month of weekly watering, three regimes were followed: weekly, bimonthly, and monthly watering. Army Corps specifications called for weekly watering of all transplants; this regime was selected to serve as the control. Rainfall of one inch or more per week was considered by the Corps to be sufficient to preclude watering. However, rainfall of less than one inch often prevented watering because site conditions were too wet for watering vehicles.

Eighteen five-gallon specimens of Cercidium floridum (Blue Palo Verde), Prosopis juliflora (Mesquite), and Larrea divaracata subsps. tridentata (Creosote) were randomly selected and assigned to the three watering regimes by use of a random numbers table. Six replications of each water treatment were included to insure a statistically testable sample. All plants were fenced.

The following chart illustrates the factorial design implemented in the east section of the dam site.

- 6 replicates
  - Creosote
    - Water 1 weekly (control)
    - Water 2 bimonthly
    - Water 3 monthly
  - Palo Verde
    - Water 1 weekly (control)
    - Water 2 bimonthly
    - Water 3 monthly
  - Mesquite
    - Water 1 weekly (control)
    - Water 2 bimonthly
    - Water 3 monthly

Soil moisture was gravimetrically determined on a weekly basis. Five branches of each transplant were marked and growth was measured relative to the marking. In addition, plants were assessed for overall vigor on a scale of one to five, with five being the highest vigor rating. Phenological aspects are also noted and monitored for each tree.

The west section of the dam was planned as a randomized block factorial design. Five blocks contained replicates of the experiment. Within each block, transplants were randomly selected and assigned to treatments through the use of a random numbers table.

This design was complicated because the landscaping scheme called for a small number of Mesquite on the west section of the site. Because these Mesquite were clumped they were studied by a simple factorial design with five replicates.

The three watering regimes established in the east section of the dam were again utilized in the west areas. Additionally, three mulch treatments were tested. These included, a pine mulch (as per Army Corps specifications), a stone mulch (material taken from on-site) and a no mulch treatment. Mulches, where applied, covered each tree well to a minimum depth of three inches. The following chart illustrates the randomized block factorial design and the simple factorial design for Mesquite utilized in the west section of the site.

Within each of five blocks

- Creosote
  - Water 1 weekly
    - Pine mulch (control)
    - Stone mulch
    - No mulch
  - Water 2 bimonthly
    - Pine mulch (control)
    - Stone mulch
    - No mulch
  - Water 3 monthly
    - Pine mulch (control)
    - Stone mulch
    - No mulch

Within each of blocks	Palo Verde	Water 1 weekly	Pine mulch (control)
			Stone mulch
			No mulch
		Water 2 bimonthly	Pine mulch (control)
			Stone mulch
			No mulch
		Water 3 monthly	Pine mulch (control)
			Stone mulch
			No mulch
Five replicates	Mesquite	Water 1 weekly	Pine mulch (control)
			Stone mulch
			No mulch
		Water 2 bimonthly	Pine mulch (control)
			Stone mulch
			No mulch
		Water 3 monthly	Pine mulch (control)
			Stone mulch
			No mulch

To determine if watering requirements change with tree size, three fifteen gallon Palo Verde transplants were randomly selected within each of the five blocks and were assigned to the three watering regimes.

Sampling was conducted on a five week rotation basis for 15 weeks. One block was sampled each week, for soil moisture, phenology, vigor and growth using the same techniques as in the east section study.

RESULTS AND DISCUSSIONS

Data documenting growth were compromised by the variability both within a single plant and between different plants. Because the variances derived from this data were so high, it was impossible to detect any significant differences between the treatments. Instead, only slight trends were observed. In general, the trees watered every week showed good growth, which was comparable to the two-week water trees. The trees watered every month demonstrated lower growth, but it is important to note that no trees died as a result of diminished watering. The growth data was further complicated by an infestation of tent caterpillars, whose destructive predation on both the Palo Verde and Mesquite transplants was devastating. Both vigor and growth dropped sharply during this period, and plants were slow to recover after the pests had been removed by application of Savin pesticide. Indeed, to speed the recovery of some specimens, it was necessary to interrupt the watering regimes established by the experiment, and to provide supplemental irrigation to the impaired trees. Fortunately, the Creosote escaped predation by these noxious pests, due to the resinous nature of the foliage, which acts as an innate deterrent to predation by these and other insects.

Aside from the period of tent caterpillar occupation, vigor rating of the transplanted species remained high, right through the worst of the summer heat and drought. It is rather significant that upon no occasion was wilting observed, both during the watering period and after removal of supplemental irrigation, in late September. Addition of water during the first summer after transplanting appeared to be important, but further testing is needed. At this point, it is

recommended that for transplanting after March, supplemental irrigation be used through the summer.

Rabbit predation was most prevalent on the Mesquite transplants, and to a lesser degree on the Palo Verde. Comparison of fenced and nonfenced Creosotes revealed the rabbits rarely, if ever, fed on the Creosotes, due to the resinous nature of the foliage, as mentioned earlier. Predation on Mesquite and Palo Verde was heavy enough to have caused severe damage to the transplants had they not been fenced. It is recommended then, that Mesquite and Palo Verde be fenced the first 3-6 months following transplanting. Transplants during this time should be allowed to develop lateral branches, which shield the main trunk from rabbit attack once the fences have been removed. Removal of the protective fences becomes necessary as the fence begins to restrict the growth of the tree.

Comparison of soil moisture for the east area transplants is presented in Figure I. The east study involved testing of three watering regimes only. When one standard deviation unit encompasses the mean of another treatment, they are considered not significantly different. For this study, the three watering regimes show overlapping means for the two periods compared. This result is significant, as it demonstrates that transplanted trees can be successfully watered on a monthly basis. It is additionally important to note that the soil moisture is significantly lower for the May through September period, than during the February through May period. Supplemental watering then, becomes more crucial as summer drought conditions begin.

Figure II not only demonstrates the test on the west area of the dam, but reveals surprisingly lower soil moisture amounts than those

FIGURE 1 MEAN WEEKLY SOIL MOISTURE FOR TRANSPLANTS EAST OF 35TH AVENUE

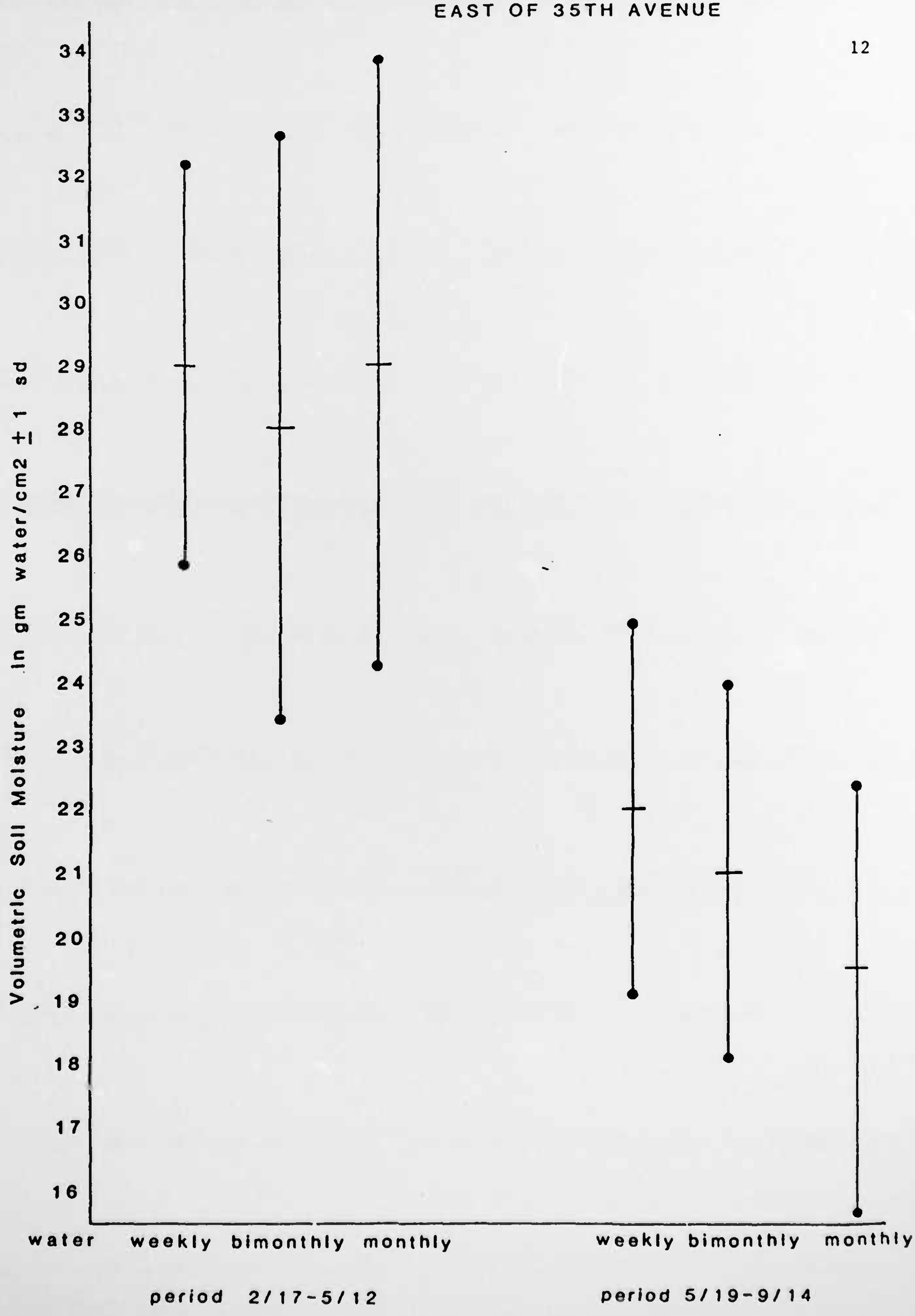
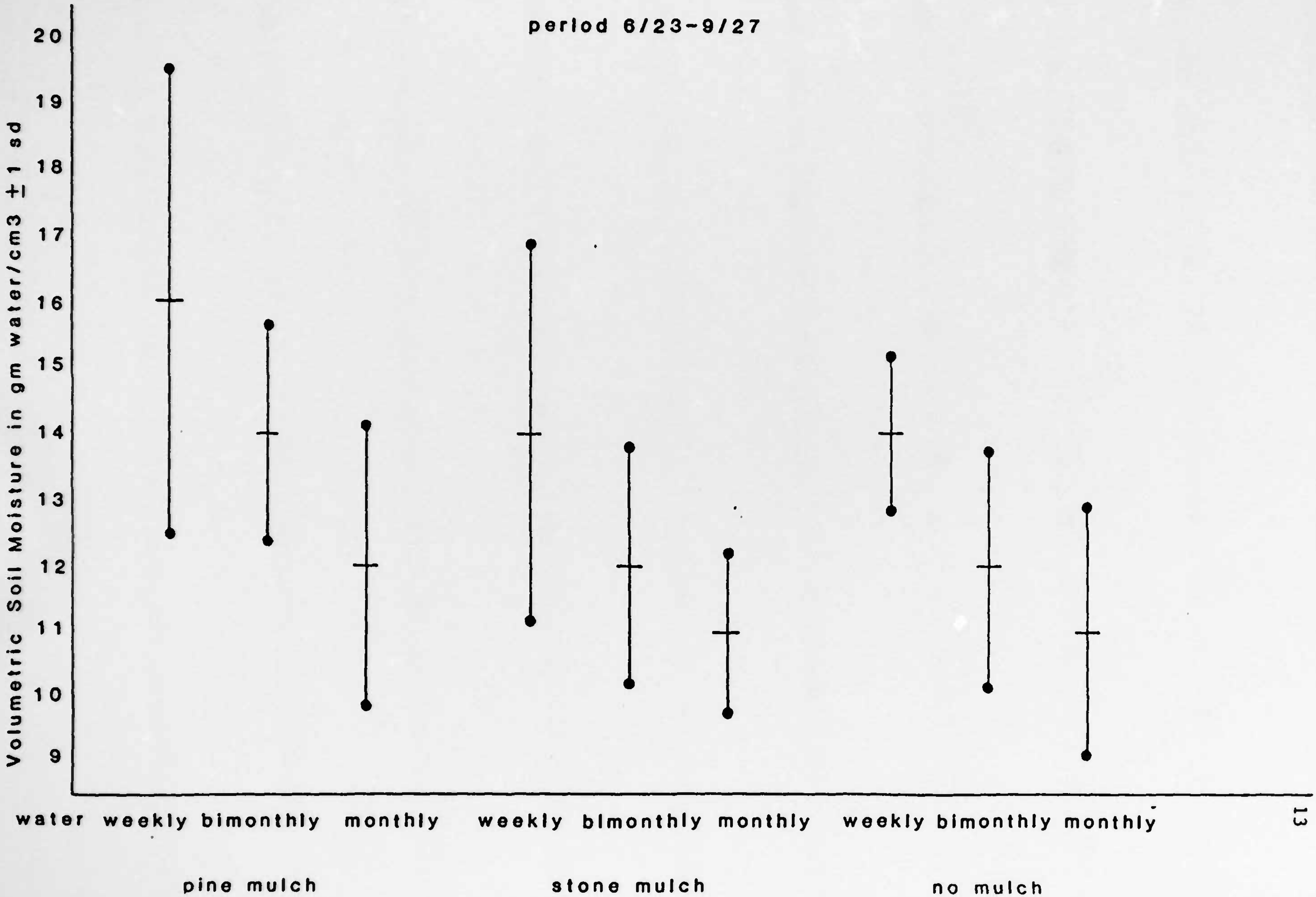


FIGURE II MEAN WEEKLY SOIL MOISTURE FOR TRANSPLANTS WEST OF 35TH AVENUE

period 6/23–9/27



observed in the east dam study, even when the similar periods are compared. It would seem that soils from the two areas have different water holding capacities and that perhaps the transplants planted later (on the west) removed more water from the sampling zone. Comparison of the three water regimes shows that the weekly water soil moistures are significantly higher than the bimonthly and monthly watering soil moistures, which as presented, are not significantly different from each other. The stone mulch was not significantly different from the pine mulch or the no mulch treatments, which were, however, significantly different from each other for the control water.

The benefits of a mulch cover, as stated earlier, merit its use on all transplanting operations. The stone mulch as tested compared favorably to the pine mulch, and additionally remained in place throughout the study. The pine mulch was washed away during the first few months of the study and therefore its beneficial effects were more short-lived.

CONCLUSIONS

On the basis of these transplant studies, it is recommended that a minimal irrigation schedule be followed in the future for transplanted specimens. Transplanting early in the year reduces the watering requirements. Furthermore, after a one month adjustment period, trees watered once a month did well. Removal of supplemental water should be gradual, so as not to cause shock to the trees. Stone mulch appears to be both durable and effective as a mulching material, and can be cost effective if readily available on site. Fencing is a requirement for Palo Verde and Mesquite transplants but can be foregone on Creosote.

Management following transplanting should include regular site inspections for signs of insect infestation and for watering problems. Inspection personnel should watch for signs that transplants have been watered adequately and that fences are intact and not restricting tree growth.

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